National Aeronautics and Space Administration

NASA's New Worlds News

The EXOPLANET EXPLORATION PROGRAM *Newsletter*

Issue 13 - April 2014

Please visit http://exep.jpl.nasa.gov/newslettersarchive-htmlfiles/2014Apr.html to view the HTML version of this newsletter.

Click here for a printable PDF

HEADLINES

*Do you have an accomplishment or event you want to share in Community Highlights? Send it to us at **nasaexoplanetnews@jpl.nasa.gov**. Please limit your submissions to no more than 150 words.*

Exoplanets at TED2014

On March 19, 2014, Jeremy Kasdin presented the starshade concept at the prestigious annual TED conference in Vancouver. For more information visit the TED blog at http://blog.ted.com/2014/03/19/blocking-light-to-see-planets-beyond-the-solar-system-jeremy-kasdin-at-ted2014/

2014 Carl Sagan Fellows Announced

Congratulations to the 2014 Carl Sagan Postdoctoral Fellows!

Visit http://nexsci.caltech.edu/sagan/2014postdocRecipients.shtml to learn more.

Kepler Challenge

Many of you can locate the Kepler field (in the constellation of Cygnus), but can you locate the constellation where Kepler itself appears to be at this time of year? Hint: the spacecraft is in an Earth-trailing heliocentric orbit, about 0.55 astronomical units from Earth, and can currently be found near a first-magnitude star.

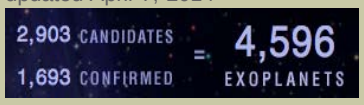
1. Program Manager's Update

By Gary Blackwood, Manager, Exoplanet Exploration Program Office

What an exciting time to be working in the field of exoplanets: the science discoveries and technology progress keep coming, new talent is being drawn into

PLANET COUNT

updated April 7, 2014



For information on any of the stories or events below, please visit: http://exep.jpl.nasa.gov/newslettersarchivelist/

EXOPLANETS IN THE NEWS

March 25, 2014
How a Giant Sunflower Will Help Us See Alien Worlds
Discovery

March 4, 2014
Every Red Dwarf Hosts at Least One Exoplanet
Discovery, **Space.com**

February 26, 2014
Kepler Telescope Bags Huge Haul of Planets
BBC, **The New York Times**, **Discovery**

February 26, 2014
Water Found in Atmosphere of Nearby Alien Planet
Discovery

February 19, 2014
European Space Agency Picks Plato Planet-Hunting Mission
BBC

February 3, 2014
Are We Searching for Aliens in the Wrong Place?
Discovery

EVENTS

and contributing to the field, and we are now designing the next generation of missions to directly image exoplanets orbiting nearby stars.

- Just last month, the Kepler Project nearly doubled the number of validated planets by promoting 715 prior planet candidates on the basis of the statistical analysis of multiplanet systems. We eagerly anticipate the discoveries that will emerge as the fourth year of Kepler transit data is mined.

- In October 2013, the Wide-Field Infrared Survey Telescope-Astrophysics Focused Telescope Assets (WFIRST-AFTA) mission entered pre-project development for a potential new start in FY17; this mission concept uses the available 2.4-meter telescope and state-of-the-art wide-field infrared detectors to deliver breakthrough science in dark energy, infrared survey, and a microlensing survey of long-period (including "rogue," or free-floating) exoplanets.

- WFIRST-AFTA now includes a visible coronagraph for direct imaging of gas-giant and ice-giant exoplanets. Between July and December 2013 over 30 members of the exoplanet community participated in a set of intense workshops to recommend a primary and a backup coronagraph architecture for the mission, which helped provide focus for near-term coronagraph design and technology investments. The consensus recommendation of the working group was made to the Astrophysics Division Director jointly by the Exoplanet Exploration Program and AFTA Study Office, and was based on the criteria of science capability, risk, technical readiness, and science opportunities.

- The WFIRST-AFTA Study Office is now conducting directed technology development of these coronagraph masks and other enabling technologies; see the technology and science articles by Ilya Poberezhskiy (http://exep.jpl.nasa.gov/newsletters/issue13/downselect/) and Wes Traub (http://exep.jpl.nasa.gov/newsletters/issue13/sciupdate/) in this newsletter.

- In parallel, the Exoplanet Exploration Program Office is developing two scientifically compelling and technologically viable probe-class ($1B) exoplanet mission concepts, one for an off-axis internal coronagraph and another for an external occulter (starshade) -- see http://exep.jpl.nasa.gov/stdt/. Interim reports by these two probe studies and by the WFIRST-AFTA mission concept were recently presented to the Committee on Astronomy and Astrophysics on March 4 -- see http://exep.jpl.nasa.gov/presentations/.

- Since October, the Large Binocular Telescope Interferometer (LBTI) has made significant progress towards commissioning by achieving closed-loop fringe tracking on the sky, described further in this newsletter by NASA LBTI Project Scientist Rafael Millan-Gabet.

- This newsletter also highlights the work of Sagan Fellow Nikole Lewis, one of 47 Fellows in the program since 1999.

The Exoplanet Exploration Program delivered a number of significant successes in 2013 and we look forward to even greater progress in 2014. The Program Office looks forward to working with each of you to advance the dynamic and growing exoplanet field.

My program overview presentation from the January AAS meeting and the Kepler Science Conference II is available at http://exep.jpl.nasa.gov/presentations/

2. Message from NASA Astrophysics Division Director

By Paul Hertz, Director, NASA Astrophysics Division

As astrophysicists, we are fortunate that our most compelling science questions -- how does the universe work, how did the familiar sky of galaxies and stars come to be, are we alone -- resonate with the American public and government policy makers who support us. At this time, we are poised to answer these questions scientifically using the suite of large and small space-based observatories spanning the

Habitable Worlds Across Time and Space - April 28-May 1
Location: Space Telescope Science Institute, Baltimore, Maryland

Biosignatures Across Space and Time - May 20-22
Location: Bergen, Norway

SPICA Science Workshop - May 21-23
Location: Leiden, The Netherlands

American Astronomical Society 224th Meeting - June 1-5
Location: Boston, Massachusetts

Diana Project Summer School on Protoplanetary Disks - June 16-20
Location: Groningen, The Netherlands

SPIE Astronomical Telescopes + Instrumentation - June 22-27
Location: Montreal, Canada

Characterizing Planetary Systems Across the HR Diagram - July 28-August 1
Location: Cambridge, England

PROGRAM WEBSITES

Exoplanet Exploration Program (ExEP)

http://exep.jpl.nasa.gov/

PlanetQuest - Public Outreach Website

http://planetquest.jpl.nasa.gov/

NASA Exoplanet Science Institute (NExScI)

http://nexsci.caltech.edu/

NASA Science Astrophysics

http://science.nasa.gov/astrophysics/

electromagnetic spectrum.

As I described during the Astrophysics Subcommittee meeting on March 26, 2014, we have made progress towards addressing the priorities of the 2010 Decadal Survey for Astronomy and Astrophysics. The appropriation that NASA Astrophysics received for FY14 and the President's FY15 budget request both support our plans for continued progress. The progress we are making toward the major recommendations of the 2010 Decadal Survey are:

- Preformulation and focused technology development for a 2.4-meter version of the Wide-Field Infrared Survey Telescope (WFIRST), a mission concept referred to as the Astrophysics Focused Telescope Assets (AFTA), are underway. NASA received $56M in directed funding for in FY 2014 for WFIRST/AFTA to continue preformulation activities and technology development. The President's FY15 budget request proposes to continue this progress with funding in FY 2015, and notional funding plans for FY 2016 and beyond, to enable a new start when funding becomes available as the James Webb Space Telescope approaches launch, no earlier than FY 2017. A National Research Council study, released March 2014, endorsed the WFIRST/AFTA mission concept and provided NASA with recommendations on managing the technical and cost risk associated with the use of the 2.4m telescope assets and the immature coronagraph technology. The NRC report is available at http://wfirst.gsfc.nasa.gov/, and reports from the Science Definition Team and other WFIRST information is available at http://wfirst.gsfc.nasa.gov/.

- The President's FY 2015 budget request includes augmentation to the Explorer program to enable more frequent flight opportunities, including a planned SMEX AO later this year (see the community announcement at http://explorers.larc.nasa.gov/APSMEX/). The notional funding plans for FY 2016 and beyond support the four AOs per decade that were recommended by the 2010 Decadal Survey.

- Strategic technology investments are being made and partnerships are being discussed with the European Space Agency in their gravitational wave and X-ray observatories.

- Strategic technology investments are being made to advance the medium scale programs including technology for exoplanet missions and technology for detection of polarization of the cosmic microwave background.

- Modest augmentations have been made to small programs, including the selection of six Theory and Computation Networks (co-funded by the National Science Foundation).

A goal of the Astrophysics Division is to be prepared to start a new strategic NASA Astrophysics mission to follow JWST as soon as funding becomes available, while continuing to advance Decadal Survey science during the interim.

The FY 2014 appropriations for NASA provides $658M for JWST and $668M for the rest of NASA astrophysics. The FY 2015 President's budget request provides $645M for JWST and $607M for the rest of NASA astrophysics. Both budgets support the continued development of JWST on plan toward its launch in 2018, and both budgets include funding for continued preformulation of WFIRST as described above. Both budgets also includes funding for several new missions including the Transiting Exoplanet Survey Satellite (TESS), the next Astrophysics Explorer mission, the Neutron Star Interior Explorer (NICER), the next Astrophysics Explorer Mission of Opportunity, and the NASA contribution to the European Space Agency's Euclid mission.

The FY 2015 President's budget request proposes placing SOFIA into storage due to its high operating cost and current constraints on the Federal domestic discretionary budget. NASA is working with current partner Germany to identify a path forward for SOFIA with greatly reduced NASA funding. Unless additional partners are able to support the U.S. portion of SOFIA costs, under this budget request NASA would place the aircraft into storage by FY 2015.

The FY 2014 appropriated budget does not included any restoration of funding for education, but it does direct SMD to continue conducting education activities and to consider consolidation at the Division level. For FY 2014, Astrophysics is consolidating its E/PO (Education and Public Outreach) portfolio into four areas - Cosmic Origins managed by Space Telescope Science Institute, Physics of the Cosmos managed by Chandra X-ray Center, Exoplanet Exploration managed by the Jet Propulsion Laboratory, Airborne Astronomy Ambassadors managed by the SOFIA program. For FY 2015 SMD will assess its portfolio of education activities and

NASA Cosmic Origins Program (COR)

http://cor.gsfc.nasa.gov/

NASA Physics of the Cosmos Program (PCOS)

http://science.nasa.gov/astrophysics/

competitively allocate funding to the highest priority education projects within NASA Science.

The major impacts of the October 2013 Government shutdown included the cancellation of the 2013-2014 Antarctic balloon campaign including three long duration balloon flights; the cancellation of nine SOFIA science flights and a delay in the beginning of Cycle 2; and delays in sending out research funding for those grantees whose awards were scheduled to start or be funded at the beginning of FY 2014.

Major activities planned for 2014 include the Astrophysics Senior Review of flight missions and release of a Small Explorer Announcement of Opportunity targeted for Fall 2014. A task force of the Astrophysics Subcommittee has completed a 30 year visionary roadmap, Enduring Quests, Daring Visions, to address enduring questions in Astrophysics.

My entire presentation to the Astrophysics Subcommittee will be available at http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/. Enduring Quests, Daring Visions, is available at http://science.nasa.gov/astrophysics/documents/.

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3. Big News from NASA's Kepler Mission

Edited by Ingolf Heinrichsen, NASA Jet Propulsion Laboratory and Nick Gautier, NASA Jet Propulsion Laboratory

While Kepler has stopped collecting data in support of its primary mission, the telescope continues to capture attention and contribute to the exoplanet discovery story. This edited piece brings together a few of Kepler's recent press releases and includes:

Planet Bonanza, 715 New Worlds

On February 26, NASA's Kepler mission announced the discovery of 715 new planets. These newly verified worlds orbit 305 stars, revealing multiple-planet systems much like our own solar system. A research team co-led by Jack Lissauer (NASA's Ames Research Center) used a new technique called verification by multiplicity. This technique relies on the fact that false positive planet indications not associated with Kepler target stars, mainly eclipsing binary stars in the background of a Kepler target star, are not very densely distributed on the sky. Therefore, if a target star shows multiple planet candidates it is very unlikely that more than one is a false positive. The normal follow-up work that Kepler does for planet candidates then can eliminate most of the remaining possibilities for false positives, producing a very clean set of multiple planet systems. "We've now developed a process to verify multiple planet candidates in bulk to deliver planets wholesale, and have used it to unveil a veritable bonanza of new worlds," says Lissauer.

Nearly 95 percent of these planets are smaller than Neptune, which is almost four times the size of Earth. This discovery marks a significant increase in the number of known small-size planets more akin to Earth than previously identified exoplanets, which are planets outside our solar system. Four of these new planets are less than 2.5 times the size of Earth and orbit in their sun's habitable zone.

The full story can be found at: http://www.nasa.gov/ames/kepler/nasas-kepler-mission-announces-a-planet-bonanza/#.U0V7Mq1dVMh

The two papers can be found here:
http://www.nasa.gov/sites/default/files/files/arXivValidationMultisII.pdf" and
http://www.nasa.gov/sites/default/files/files/arXivValidationMultisIII.pdf.

Kepler Marks Five Years in Space

NASA's Kepler Space Telescope celebrated its five-year launch anniversary on March 6. In five years of operation, Kepler's data have revealed more than 3,600 candidate planets and confirmed 961 of those candidates. Because of Kepler, we now know that most stars have planets, Earth-size planets are common, and planets quite unlike those in our solar system exist.

In August 2013, the mission ended its science observations after a second faulty reaction wheel affected the telescope's ability to point precisely. The mission may be able to operate in a different

mode and continue to do science. New mission proposals will be considered for funding by NASA in the 2014 Astrophysics Senior Review of Operating Missions.

You can read more about Kepler's anniversary here: http://www.nasa.gov/ames/kepler/kepler-marks-five-years-in-space/#.U0V8U61dVMi

Kepler Mission Manager Update: Loss of a Science Module

During a scheduled test, we were very encouraged to see that the spacecraft operated using the fine-guidance sensors mounted on the focal plane. Having now brought the data back from the spacecraft, we have found that during the test, one of the science detector modules failed.

The Kepler focal plane is made up of a mosaic of 21 science detector modules. Four years ago, less than a year into the mission, one of the modules (Module 3) failed. An extensive review was unable to determine a specific cause, but was able to isolate the problem to a part failure in the circuitry powering that module. The new failure, Module 7, appears to be another occurrence of the same, or a very similar, problem. We have only begun our assessment of the problem, but it is likely to be another isolated occurrence of a part failure. The remaining 19 modules still allow for a very large view of the sky, and the target resources that would have fallen on Module 7 have been reassigned to the remaining modules. At this time, it does not appear that this will have any impact on future use of the telescope.

National Space Club Honors Kepler's Planet Hunters

The Kepler Team received the National Space Club's preeminent award, the Dr. Robert H. Goddard Memorial Trophy. The citation reads: Kepler has revolutionized exoplanet science and stellar astrophysics by expanding the galactic census of exoplanet candidates and fundamentally altering our understanding of our place in the galaxy. This honor is afforded Kepler in recognition of their significant contribution to U.S. leadership in the field of rocketry and astronautics.

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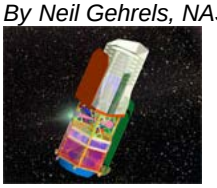
4. WFIRST-AFTA Interim Report Due April 2014

By Neil Gehrels, NASA Goddard Space Flight Center



These are exciting times for the Wide-Field Infrared Survey Telescope-Astrophysics Focused Telescope Assets (WFIRST-AFTA), with significant funding coming from congressional interest in the mission and from NASA. The mission development is preparing for a possible new start in Fiscal Year 2017, but there is a lot of work to do before that in defining the science requirements and advancing needed technologies.

The Science Definition Team (SDT) is completing its first year of studies with an Interim Report due in April 2014. The final report will come out in January 2015.

The capabilities of the current WFIRST-AFTA configuration are impressive. The 2.4-meter telescope provides Hubble-class imaging over larger portions of the sky. The size of the images on the sky is 100 times as large as for Hubble. Also, the microlensing survey and coronagraph instrument will make the next big step in exoplanet understanding following the existing and planned exoplanet missions: Kepler, Transiting Exoplanet Survey Satellite (TESS) and Planetary Transits and Oscillations of stars (the European Space Agency's Plato mission). The SDT is having fun thinking of all the discovery science that the mission can achieve.

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5. Coronagraph Concepts Selected for WFIRST-AFTA

By Ilya Poberezhskiy, NASA Jet Propulsion Laboratory

A coronagraph is an optical instrument that suppresses light from bright objects in order to see much fainter ones nearby, whose light would normally be drowned out. It was invented to view the corona of the Sun - hence the name - by French astronomer Bernard Lyot in 1930. A different type of this instrument, called a stellar coronagraph, allows direct imaging of exoplanets around nearby stars.

Compared to other methods of exoplanet detection, direct imaging allows us to measure an exoplanet's spectrum, thus providing information about atmospheric composition, which can in turn give us clues about the presence of water and, potentially, life. Circumstellar disks are also coronagraph science targets.

To give you a rough idea about the challenge of building a coronagraph for imaging large known exoplanets around nearby stars, we must be able to see a planet that is about a billion times fainter than the star, when the angular separation between these two mismatched objects is comparable to them being just a few meters apart when observed from 4000 km away (the distance from New York to Los Angeles).

This is why NASA's decision to add a coronagraph to the Wide-Field Infrared Survey-Astrophysics Focused Telescope Assets (WFIRST-AFTA) mission concept triggered a rigorous technology evaluation process during summer and fall 2013. The Exoplanet Exploration Program (ExEP) and the WFIRST-AFTA Study Office led the assessment of six submitted coronagraph technologies on parameters such as their science return (e.g., the number of known exoplanets whose spectra the coronagraph can measure in the allotted time), complexity, compatibility with the 2.4-meter AFTA telescope, and technical maturity.

The recommendation (see http://wfirst.gsfc.nasa.gov/science/AFTA_Coronagraph_Arch_Selection/Coronagraph_Downselect_Rec_Dec13_2013.pdf to view the presentation) that emerged from this process was to pick a primary coronagraph design named an Occulting Mask Coronagraph that combines two technical approaches, Shaped Pupil and Hybrid Lyot, in one instrument. The Phase-Induced Amplitude Apodization Complex Mask Coronagraph (PIAA-CMC) was selected as the backup design. These technical approaches are briefly described below:

- The **Shaped Pupil coronagraph**, pioneered by Professor Jeremy Kasdin and his group at Princeton University, is a relatively simple and mature design that uses a carefully optimized binary pupil mask to diffract on-axis starlight in a way that directs the bulk of it to be blocked by a field stop in the focal plane. The slightly off-axis planet light is passed through the field stop and then reimaged to a detector.

- The **Hybrid Lyot coronagraph**, proposed by Dr. John Trauger and his collaborators at JPL, also utilizes a simple architecture and has achieved record starlight suppression levels in a laboratory testbed. In the heart of this coronagraph is a small focal plane mask with carefully optimized layers of nickel and dielectric which create a profile of intensity and phase transmission that stops the bulk of the starlight and sends the rest of the light toward a so-called Lyot stop in the pupil plane. The Lyot stop blocks the remaining starlight but passes the light from the planet.

- Finally, the backup **PIAA-CMC** is based on the PIAA concept invented about a decade ago by Professor Olivier Guyon of the University of Arizona and Subaru Telescope. This concept is also based on modifying, or "apodizing," the telescope pupil. In contrast to the Shaped Pupil method which uses a binary amplitude mask, PIAA relies on reflections from two carefully shaped aspheric mirrors to achieve this goal. Together with Dr. Ruslan Belikov from NASA's Ames Research Center, Dr. Guyon proposed a modified PIAA concept for the WFIRST-AFTA coronagraph that uses easier-to-make PIAA mirrors and adds a phase mask in the focal plane. The PIAA-CMC concept promises the greatest science return, but has less technical heritage and is somewhat more complex than the other two approaches.

All three coronagraphs work in conjunction with deformable mirrors that shape the light coming from the telescope to achieve the necessary starlight suppression.

It is interesting to note that generally these coronagraphs work best with a clear, unobscured pupil provided by an off-axis telescope. The AFTA 2.4-meter telescope, however, is taken "as is" and has a central obscuration consisting of the secondary mirror and the struts that support it.

The selected coronagraph design teams came up with effective solutions to accommodate this

pupil shape, and going through this exercise will produce extra payoff down the line. The New Worlds telescope that is more than a decade away will need to have a significantly larger aperture than 2.4 meters in order to image Earth-like exoplanets that are even fainter and closer to the star than WFIRST-AFTA coronagraph targets. This telescope will thus likely be segmented, in which case it also will not have an ideal unobscured pupil. Thus, the technologies we will mature for the WFIRST-AFTA coronagraph are not just valuable for the science this mission will produce, but also as a stepping-stone to future missions that promise even greater discoveries.

The WFIRST-AFTA coronagraph team has drafted and started executing a plan to mature these coronagraph technologies and get them ready for flight. We expect to see some initial exciting results during 2014. Stay tuned!

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6. Science Update: Water from Radial Velocity and More!

By Wes Traub, NASA Jet Propulsion Laboratory

Water from Radial Velocity. Using spectral cross-correlation of radial-velocity (RV) spectra in the L band, the non-transiting orbit of hot Jupiter tau Boo b was improved and, surprisingly, water vapor detected, by Lockwood et al., see http://iopscience.iop.org/2041-8205/783/2/L29/pdf/apjl_783_2_29.pdf.

Gemini Planet Imager success! The Gemini Planet Imager (GPI) coronagraph was installed at the 8-meter Gemini South telescope in January, and was an instant success on the sky, according to Bruce Macintosh. Near-infrared images of beta Pic b and the disk around HR 4796 A are visual proof, at http://planetimager.org/.

Runaway greenhouse limit. By moving from a 1-D to a 3-D atmospheric model of an Earth-like planet, Leconte et al., in http://www.nature.com/nature/journal/v504/n7479/full/nature12827.html, find that Hadley cell circulation has a stabilizing effect, yielding a value of about 0.95 AU for the inner edge of the habitable zone for the present Earth-Sun system, fortuitously close to older estimates, according to Kasting and Harman: see http://www.nature.com/nature/journal/v504/n7479/full/504221a.html.

Mass from spectra. Exploiting the fact that atmospheric scale height varies as the mass of a planet, de Wit and Seager (http://www.sciencemag.org/content/342/6165/1473.full.pdf) found that it should be possible to estimate that mass solely from a transit spectrum, at least in cases where the degeneracy with temperature, radius, and mean molecular weight can be disentangled.

Clouds or hydrogen-poor? The lack of spectral features in the near-infrared spectra of GJ 1214b prompts Kreidberg et al. to infer that the planet has high clouds, but a similarly flat spectrum in the same spectral range for GJ 436b encourages Knutson et al. to conclude that that planet has either high clouds or a hydrogen-poor atmosphere, all of which suggests that more data are needed; the side-by-side papers are at http://www.nature.com/nature/journal/v505/n7481/full/nature12888.html and http://www.nature.com/nature/journal/v505/n7481/full/nature12887.html respectively, with commentary by Moses at http://www.nature.com/nature/journal/v505/n7481/full/505031a.html.

Plate tectonics redux. A new model of the Archaean era (4 to 3.5 billion years ago) on Earth features numerous volcanic “heat pipes” to the surface, allowing heat to escape while also allowing the surface layer to remain relatively cool. This means that Earth may have switched quickly from a static crust to a plate-tectonic crust around the end of this era, with implications for exoplanets; Moore and Webb report on this at http://www.nature.com/nature/journal/v501/n7468/full/nature12473.html, with commentary by Moresi at http://www.nature.com/nature/journal/v501/n7468/full/501496a.html.

Brown Dwarf maps. Crossfield et al. applied the Doppler imaging technique from stars to a nearby brown dwarf to obtain images of the surface through a full rotation period, with about 10 percent brightness variations. The paper is at http://www.nature.com/nature/journal/v505/n7485/full/nature12955.html and a commentary by Showman is at http://www.nature.com/nature/journal/v505/n7485/full/505625a.html

Read more of this science roundup **here...**

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7. The LBTI Closes the Loop, Detects First Exozodi Dust!

By Rafael Millan-Gabet, Caltech

The Large Binocular Telescope Interferometer (LBTI, P.I. Phil Hinz, University of Arizona) has been busy with almost monthly commissioning runs for the mid-infrared Nulling mode, and science observations in a variety of areas using the other LBTI modes. In December 2013 we had a big breakthrough in Nulling commissioning, when the phase loop was closed on-sky for the first time. This was the remaining sub-system to be commissioned, and the LBTI is now operating as a fully integrated system, and performing science-quality nulling observations on-sky. However, we still have significant work ahead of us to calibrate the nulls to 0.0075% (1sigma) in order to reach the required exo-zodi sensitivity (3 zodi Level 1 requirement, for nearby Sun-like stars). Improvements are needed both in the phasing algorithm, and in tracking down and eliminating vibrations that appear to originate at the telescopes.

As we work in those areas, we have begun obtaining science verification data on exo-zodi targets (the HOSTS survey) in order to accurately characterize and understand the current performance limitations (null calibration to 0.3%, or 125 zodis on average for the HOSTS target list). These data also provide valuable scientific contributions, as new spatial and sensitivity regimes are being probed, and help identify the best targets for detailed characterization in follow up observations. Five targets have been observed thus far, including the first LBTI detection of a (known) debris disk, around the star eta Corvi. We have one more run this season, in May 2014, before the Summer shutdown due to the Monsoon season. The science team has been busy refining the target list, participating in observing runs, and working with the instrument team in data reduction and developing optimum algorithms for null calibration. Talks and posters were presented at the AAS meeting in Washington, DC (Jan 2014) and the Exoplanets, Biosignatures and Instruments conference in Tucson, AZ (March 2014).

In the meantime, the exoplanet imaging survey (LEECH, P.I. Andy Skemer, University of Arizona) is continuing its observations of nearby stars to search for gas-giant exoplanets. LEECH is reaching unprecedented contrasts at 4 microns, where gas-giant exoplanets emit most of their light, and adaptive optics performance is superb. In the last several months, we have observed a large number of survey targets and also spectro-photometrically characterized known directly-imaged exoplanets from 3-4 microns.

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8. Probing the Weather on Distant Worlds

By Nikole Lewis, Sagan Fellow, Massachusetts Institute of Technology

Even planets around distant stars need an accurate weather forecast. For many of the Jupiter-size exoplanets orbiting close to their host stars, that forecast calls for extreme temperatures and winds approaching, and sometimes exceeding, the local speed of sound. My work as a Sagan Fellow focuses on trying to understand the complex weather patterns (winds, temperature, chemistry, and clouds) that exist in exoplanet atmospheres. To accomplish this goal, I combine information from exoplanet observations with predictions from general circulation models to paint a picture of the global-scale weather patterns present in exoplanet atmospheres. My observational efforts to probe exoplanet weather include monitoring the planet during the entirety of its orbit, so called phase-curve observations, and repeated observations of the planet as it passes behind its host star, so called eclipse-mapping observations, at a variety of infrared and visible wavelengths. These observations provide rough thermal maps that can be compared and contrasted with predictions from my sophisticated three-dimensional atmospheric models to understand the physical processes at work in these alien atmospheres.

Read more about Nikole at http://www.mit.edu/~nklewis

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9. Community Highlight: Sara Seager Speaks at the Goddard Memorial Symposium

On March 5 2014, Professor Sara Seager of MIT, chair of the Exo-S (Exoplanet Starshade) Science and Technology Definition Team (STDT), spoke at the Goddard Memorial Symposium, an event attended by hundreds including NASA leadership and NASA Administrator Charlie Bolden. The title of the talk was "Are We Alone? Seeking Life Among the Nearby Stars." In her talk, Sara spoke not only about the scientific approach to answering this age-old question, but also about the recent work of Exo-S, the Exoplanet Starshade Probe mission, being studied by the STDT. The mission concept consists of a 1.1-meter commercially available telescope and a 34-meter flower-shaped starshade flying in formation at a relative distance of 37,000 km, together in an Earth-leading orbit. The talk featured a 2/3-scale (4-meter) engineering model of a starshade petal recently used in the deployment tests.

The starshade was recently featured in a Space.com which can be found at http://www.space.com/25172-starshade-alien-earth-exoplanets-incredible-tech.html. In addition, a new video featuring hardware demonstration has been produced by ExEP and can be found at http://www.jpl.nasa.gov/news/news.php?release=2014-089.

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10. Did You Know? Presentations Page on ExEP Website

Did you know that you can find many of the presentations from recent exoplanet meetings (including most of those mentioned here) on the ExEP Presentations page at http://exep.jpl.nasa.gov/presentations/?

On this page you can find presentations to the **Committee on Astronomy and Astrophysics (CAA)** Meeting (March 3-5, 2014), reports from **NASA's Astrophysics Program Analysis Groups** including: Scott Gaudi's ExoPAG Report from January 2014 223rd AAS Meeting, The Future of NASA's Exoplanet Exploration Program presentation at the **Kepler Science Conference**, and the complete set of presentations from the American Astronomical Society **ExEP Evening Session** (January 7, 2014), as well as presentations about the **AFTA Coronagraph Architecture Selection**.

Some particular presentations of note include:

- HQ Direction on AFTA FY14 Coronagraph Technology Investment
- Coronagraph Architecture Downselect Recommendation by ExEP PO and AFTA SO - Gary Blackwood and Kevin Grady, 12/13
- WFIRST-AFTA Presentation to the Committee on Astrophysics - Neil Gehrels
- Presentation of Interim Report to the CAA (Exo-S) - Sara Seager
- Presentation of Interim Report to the CAA (Exo-C) - Karl Stapelfeldt

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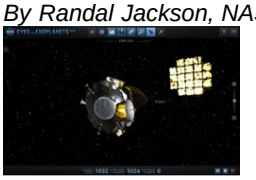
11. Grid Expectations: NASA's 'Eyes' Brings Kepler Discoveries into Focus

By Randal Jackson, NASA Jet Propulsion Laboratory



While all of the nearly 1,700 known exoplanets are visualized in NASA's "Eyes on Exoplanets" application, the 900+ confirmed discoveries of the Kepler space telescope now take center spotlight. A newly added Kepler mode, accessible from the top navigation bar, reveals the mission's cone of discoveries extending more than 7,000 light-years from our solar system, including all of the 715 new planets announced in February. Controls within the application allow users to display Kepler's confirmed discoveries, candidate planets, or both at the same time, and users can scroll outward to see the discovery space in the overall context of our Milky Way galaxy. Viewing the Kepler search space from Earth reveals all of the discovered systems in a grid pattern that matches the layout of Kepler's CCD array.

"Eyes" is powered by NASA's Exoplanet Archive and is available at http://eyes.jpl.nasa.gov/exoplanets/index.html. "Eyes on Exoplanets" was developed by the Visualization Technology Applications and Development group at JPL under sponsorship of the Exoplanet Exploration Program.

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